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[54] METHOD OF PRODUCING TONES OF A
PREFERABLY SUBSTANTIALLY
EQUAL-TEMPERED SCALE

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Related U.S. Application Data

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abandoned.

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84/DIG. 11

[51] Int. Cl. G10h 5/00

[58] Field of Search 84/1.01, 1.03, 1.11,
84/1.19, 1.22-1.24, DIG. 11

[56]

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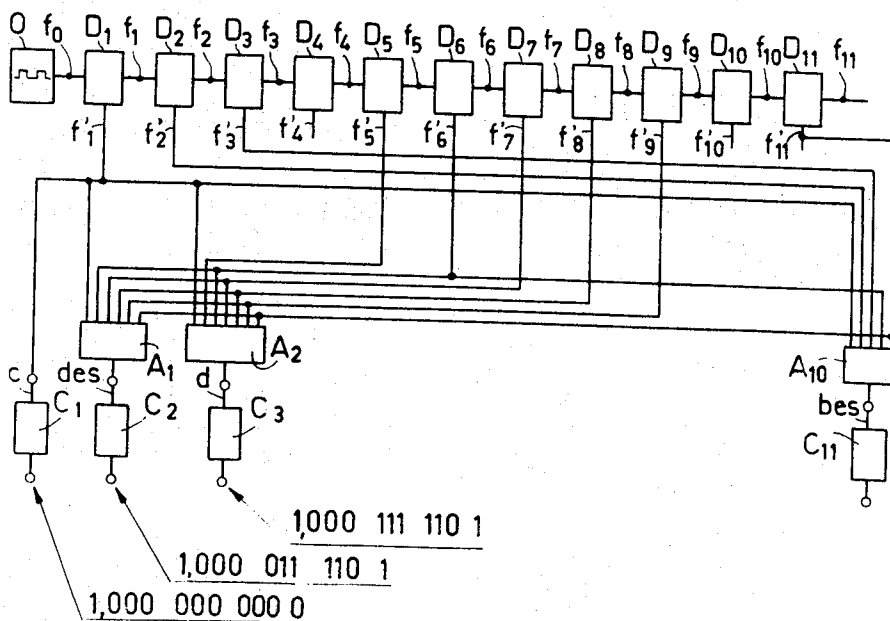
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[57]

ABSTRACT

A device for producing the tones of a musical scale from a single tone generator using a series-connected group of digital dividers for successively dividing the generated tone by 2^n . The output pulses of selected dividers are combined in logic circuits to form the individual frequencies of the musical scale.

14 Claims, 12 Drawing Figures



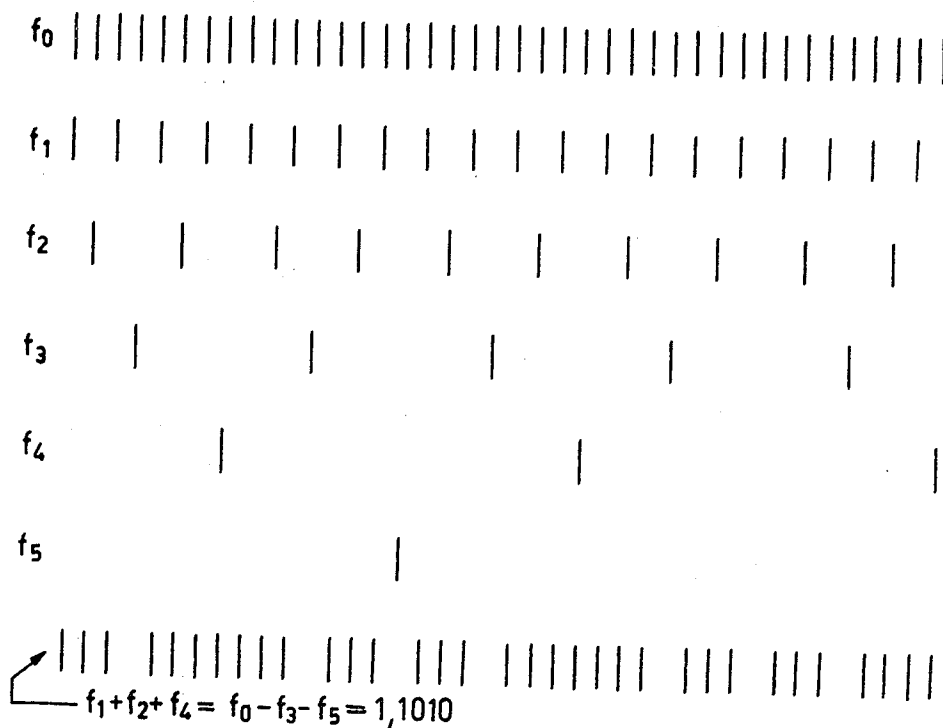


fig.1

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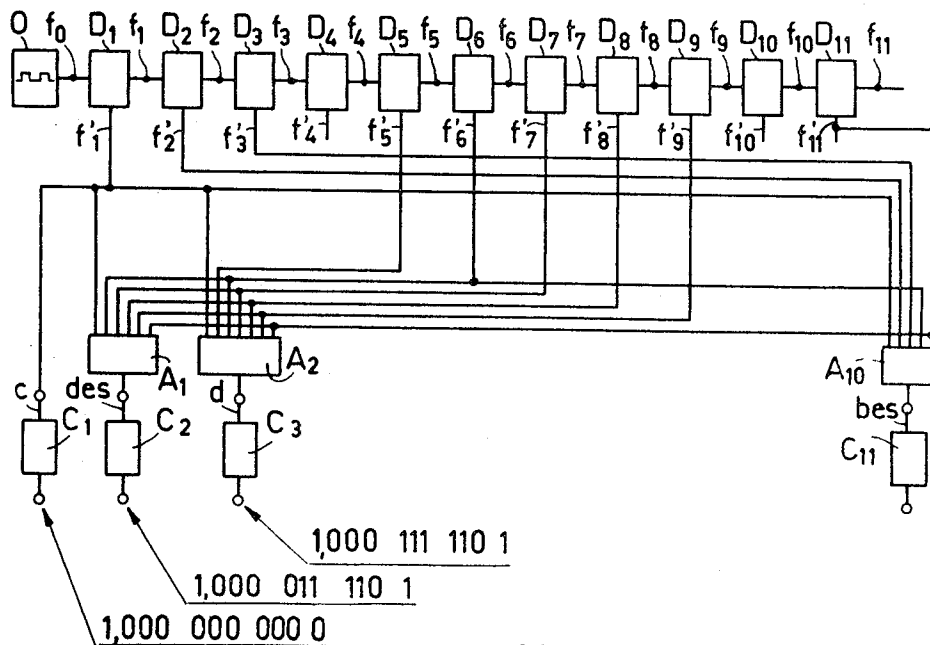


fig. 2

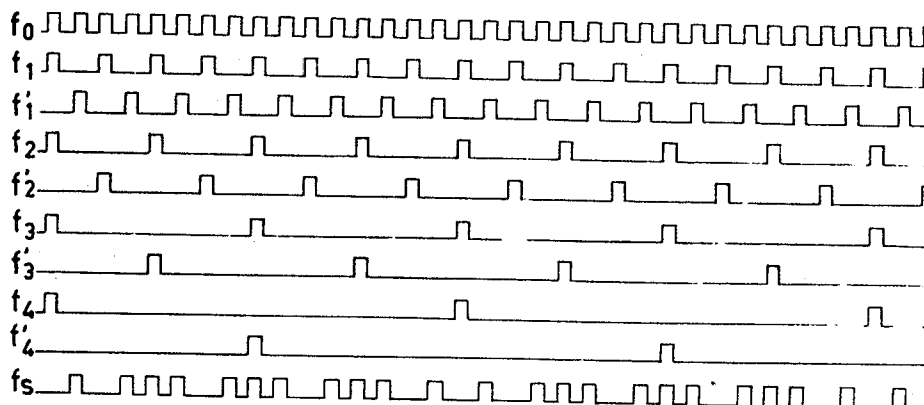


fig. 3

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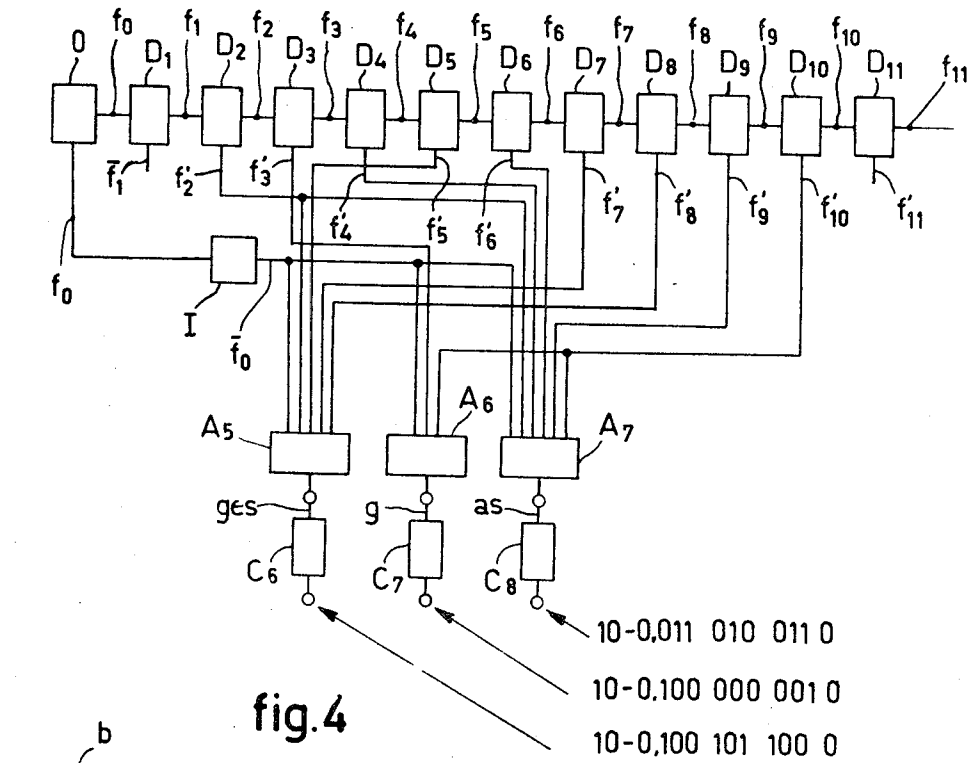


fig.4

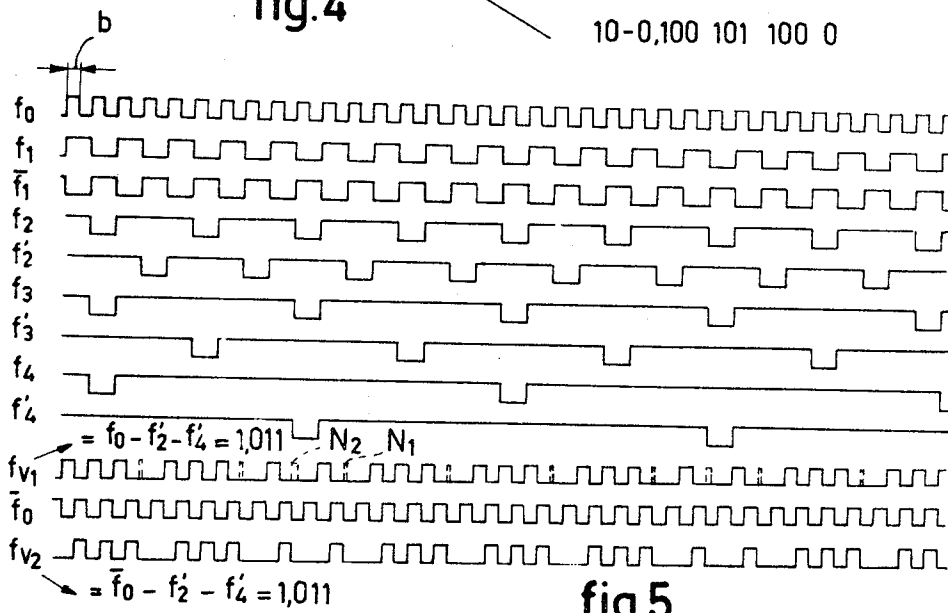


fig.5

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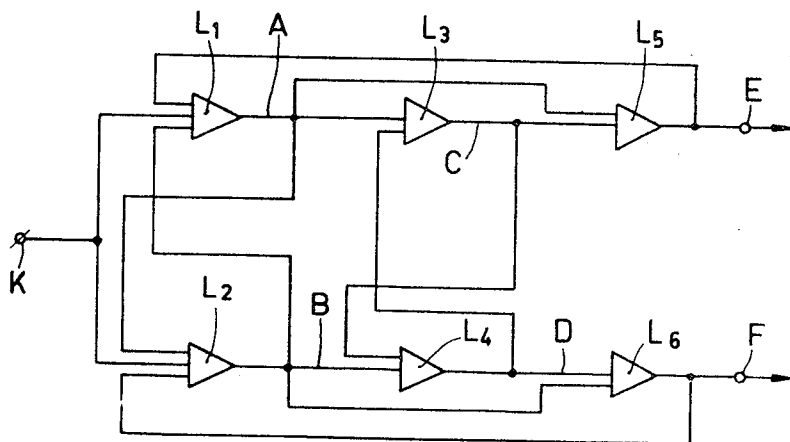


fig. 6

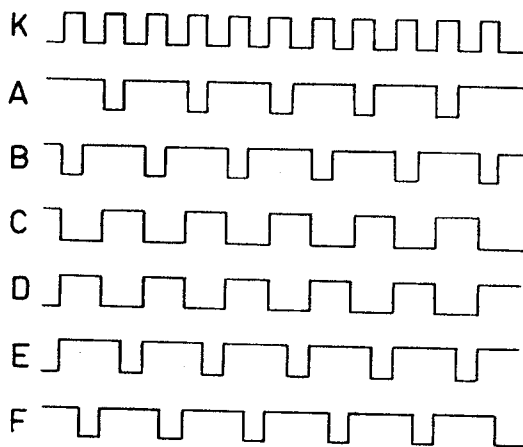


fig. 7

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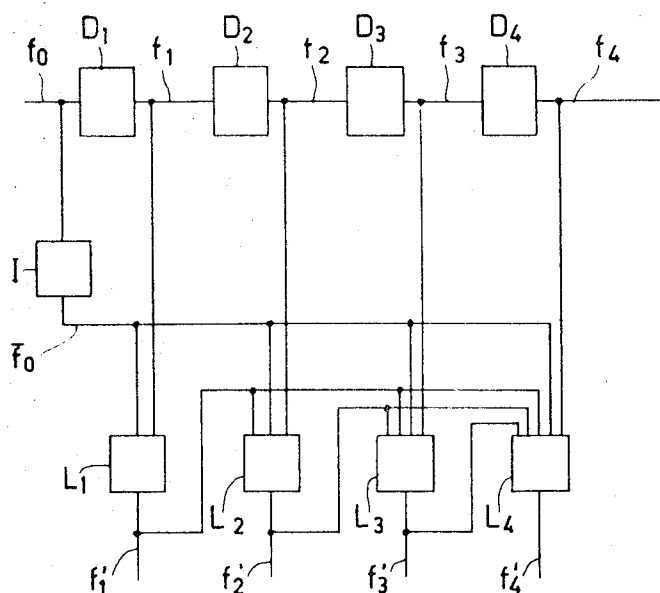


fig.8

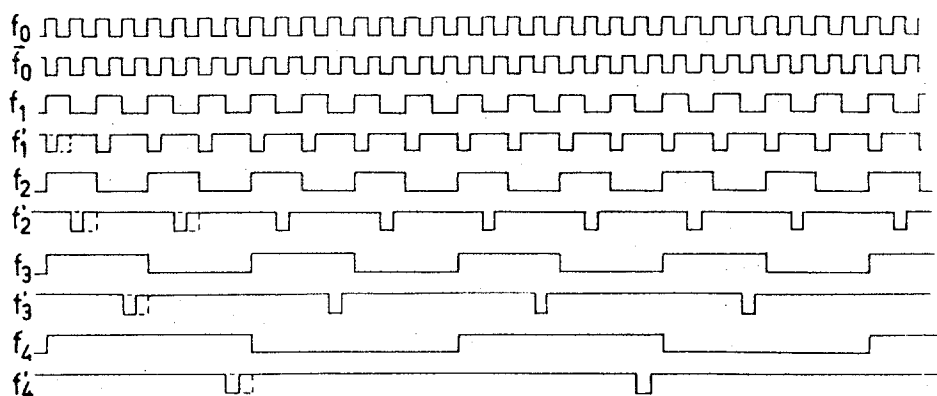


fig.9

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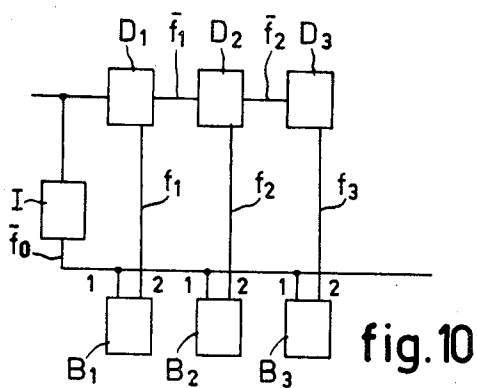


fig.10

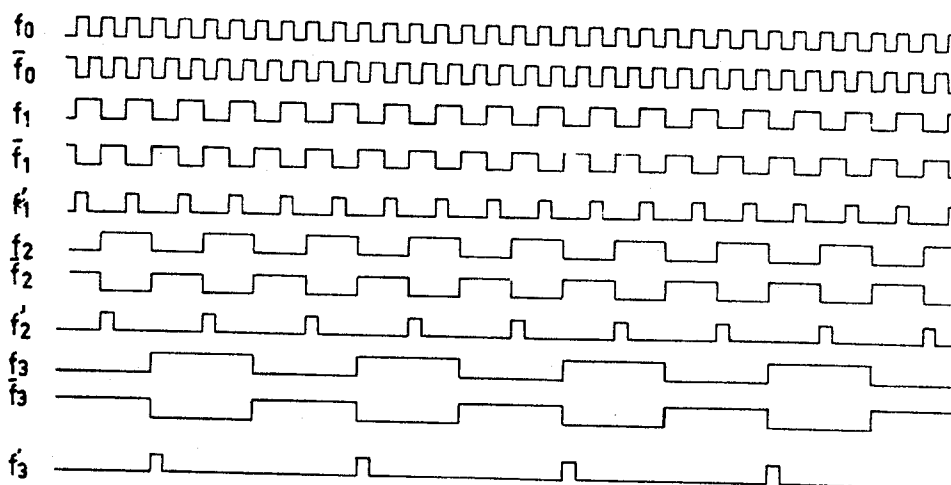


fig.11

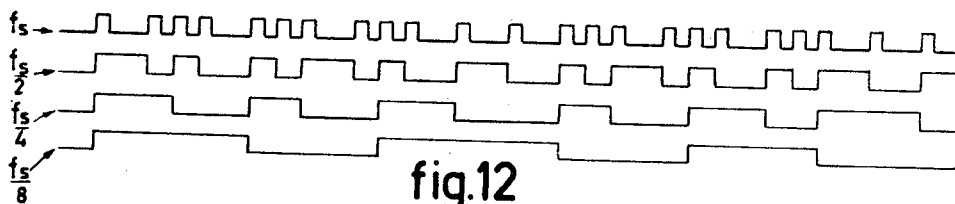


fig.12

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METHOD OF PRODUCING TONES OF A PREFERABLY SUBSTANTIALLY EQUAL-TEMPERED SCALE

This application is a continuation of application, Ser. No. 797,914, filed Feb. 10, 1969, now abandoned.

The invention relates to a method of simultaneously producing tones of a preferably substantially equal-tempered scale in an electronic musical instrument.

In a method known from U.S. Pat. No. specification 2,486,039, use is made of a number of individually operating oscillators equal to the number of tones per octave, which oscillators are each tuned to a different pitch. The tones lying one or more octaves lower are derived by means of divide-by-two circuits (2-dividers) from the said 12 tones.

It will be appreciated that detuning of one or more of these oscillators results in one or more derived tones also being detuned so that the instrument becomes false.

In the method according to the invention, this disadvantage is avoided in that at least one signal determines the position of the scale and in that each of the remaining tones of the octave is built up of pulse sequences obtained by continued division of the first signal.

In this application, the term "frequency" is employed to signify the pulse recurrence frequency, i.e., the number of pulses per second. A strictly regular pulse sequence is no longer considered. The extent of variation of the pulse distance determines whether this pulse sequence is perceived subjectively as an acceptable tone.

This method permits the generation of of any arbitrary interval with any desired degree of accuracy. For example, the interval of a minor second of the equally tempered scale, which interval is equal to $12\sqrt{2} = 1.059463$, may be built up by deriving from the lowest frequency of the interval by continued division by ten pulse sequences having frequencies of 10^{-1} , 10^{-2} , 10^{-3} , 10^{-4} , 10^{-5} and 10^{-6} times the lowest frequency and by adding to the pulse sequences of the lowest frequency of 10 pulses each through an adding circuit 0 pulses of 10^{-1} , 5 pulses of 10^{-2} , 9 pulses of 10^{-3} , 4 pulses of 10^{-4} , 6 pulses of 10^{-5} and 3 pulses of 10^{-6} times the lowest frequency. This method starts from the octave tone of the lowest frequency and the lowest frequency is obtained therefrom by division by two. Of course, it is also possible to start from the highest frequency and to obtain the lower tones by subtracting the suitable pulse sequences through an adding circuit from the highest frequency while a combination of addition and subtraction may also be used. The term "subtraction" is to be understood to mean herein the addition of a negative number.

In the same manner, any arbitrary scale can be derived from one frequency by using instead of the decimal system another numerical system, for example, the ternary system, while the desired frequency can be built up by means of the pulse sequences appearing at the outputs of a chain of dividers by three.

In a particularly advantageous embodiment of the method according to the invention, each subsequent pulse sequence is derived from the preceding pulse sequence by division by two. For this purpose the decimal values of the desired intervals are converted into values of the binary system. The following Table gives the decimal numbers for the tones of the natural tuning followed by the binary values, the frequency of the C being standardized at 1.000.000.0.

C	= 1.000 000 0	1.000 000 000 0
D flat	= 1.066 666 6	1.000 100 010 0
D	= 1.125 000 0	1.001 010 000 0
E flat	= 1.200 000 0	1.001 100 110 1
E	= 1.250 000 0	1.010 000 000 0
F	= 1.333 333 3	1.010 101 010 1
F sharp	= 1.406 250 0	1.011 010 000 0
G	= 1.500 000 0	1.100 000 000 0
A flat	= 1.600 000 0	1.100 110 011 0
A	= 1.666 666 6	1.101 010 101 1
B flat	= 1.800 000 0	1.110 011 001 1
B	= 1.875 000 0	1.111 000 000 0
C'	= 2.000 000 0	10.000 000 000 0

An oscillator supplies pulses having the frequency of the C' to a first divider by two, the frequency associated with the C occurring in the usual manner at the output of the first divider by two. The D flat is now built up by adding together the pulse sequences derived from an output of the first, the fifth and the ninth dividers by two. The remaining tones can be attained in the same manner. Alternatively, instead of adding pulse sequences together in the manner described, the D flat may be derived from the C' pulse sequence by subtracting the number 0.111 011 110 0 from 10.000 000 000 0. That is to say that the pulses occurring at the outputs of the first, the second, the third, the fourth, the sixth, the seventh, the eighth and the ninth dividers by two are each caused to suppress a pulse from the original pulse sequence. It may also be advantageous to use a combination of addition and subtraction. The remaining tones of the scale can be obtained in an analogous manner. This also applies to other tuning operations, for example, the intermediate tone tuning, the intervals of which are stated in the following Table in decimal and binary values.

C	= 1.000 000 0	1.000 000 000 0
D flat	= 1.070 000 0	1.000 100 100 0
D	= 1.118 065 7	1.000 111 100 1
E flat	= 1.196 296 0	1.001 100 100 1
E	= 1.250 000 0	1.010 000 000 0
F	= 1.337 537 6	1.010 101 101 0
F sharp	= 1.397 582 2	1.011 001 011 1
G	= 1.495 370 0	1.011 111 101 1
A flat	= 1.600 000 0	1.100 110 011 0
A	= 1.671 921 9	1.101 011 000 0
B flat	= 1.788 905 2	1.110 010 100 0
B	= 1.869 212 5	1.110 111 101 0
C'	= 2.000 000 0	10.000 000 000 0

The 31-tone scale having a minimum interval equal to $31\sqrt{2} = 1.022 611 5$ and the commonly used equal-tempered scale having a minimum interval equal to $12\sqrt{2}$ can also be obtained in the same manner, from which follow the pitches relative to the frequency of the C standardized at 1.000 000 which are stated in the Table below.

C	= 1.000 000	1.000 000 000 0
D flat	= 1.059 463	1.000 011 110 1
D	= 1.122 462	1.000 111 110 1
E flat	= 1.189 207	1.001 100 001 0
E	= 2.259 921	1.010 000 101 0
F	= 1.334 840	1.010 101 011 1
G flat	= 1.414 214	1.011 010 100 0
G	= 1.498 307	1.011 111 111 0
A flat	= 1.587 401	1.100 101 101 0
A	= 1.681 793	1.101 011 101 0
B flat	= 1.781 797	1.110 010 000 1
B	= 1.887 749	1.111 000 110 1
C'	= 2.000 000	10.000 000 000 0

If the above intervals should be defined with a higher or a lower degree of accuracy, it is sufficient to increase or to decrease the number of 2-dividers and to connect the required number of outputs to the adding circuit until the desired degree of accuracy is attained.

It should be ensured that the pulses occurring at the outputs of the 2-dividers and, as the case may be, the pulses of the signal of the master oscillator never coincide. For this purpose, in a further embodiment of the method according to the invention, the frequencies are built up of pulse sequences the pulses of which are located each time at least approximately midway between the pulses of the preceding divider by two. In case the divider by two is constituted by a bistable multivibrator, this can be achieved by deriving the control from one output pulses and the desired pulses sequence from the other one.

In an embodiment of a device for carrying out the method, the output of a master oscillator which, if required through a pulse shaper, gives off pulses having a width of at least approximately 50 percent of the period and therefore a 50% duty factor, is connected to a chain of dividers by two. A first output of each divider by two is connected to the input of the next divider by two which divider by two supplies at least at a second output, if required through a pulse-width convertor, pulses having an absolute pulse width at least substantially equal to that of the pulses at the input of the first divider by two. Absolute pulse width is defined as the width of the narrowest positive or negative excursion of a repetitive series of pulses. The second outputs of the divider by two required for the formation of the signals of the desired tone are connected to the inputs of an "OR" circuit from the output of which the desired tone can be derived. The "OR" circuit adds the pulses together. The tone is thus composed of the sum of the signals of the relevant dividers by two. In another embodiment of a device for carrying out the method, in which the tones are obtained from the difference between the pulse sequences of the master oscillator and the pulse sequences of the dividers by two, the output of a master oscillator, which, if required through a pulse shaper, gives off pulses having a width at least approximately equal to 50 percent of the period, is connected to a chain of dividers by two. A first output of each divider by two is connected to the input of a next divider by two which divider by two supplies at least at a second output, if required through a pulse-width convertor, pulses having an absolute pulse width which is smaller than three times the period and larger than or equal to the absolute pulse width of the pulses of the master generator. The input of the first divider by two is connected together with the second outputs of selected other dividers by two for the formation of the signals of the desired tone to the inputs of an "AND" circuit from the output of which the desired tone can be derived. In an advantageous embodiment of a device for carrying out the method according to the invention, the dividers by two comprise logical circuits each provided with a number of inputs and an output at which a voltage may occur at two levels. The voltage occurs at the first level if at least one of the voltages at the outputs has a first value, while the voltage occurs at the second level if the voltages at the inputs all have a second value. The input signal is applied to a first input both of a first and of a second logical circuit. The outputs of the first and of the second logical circuit are connected to a first input of a third and of a fourth logical circuit, respectively. The outputs of the third and fourth logical circuit, respectively are connected to a first input of a fifth and of a sixth logical circuit. The outputs of the fifth and sixth logical circuits, respec-

tively are connected on the one hand to a first and to a second output terminal, and on the other hand to a second input of the first and of the second logical circuit. The outputs of the first and of the second logical circuit are moreover connected on the one hand to a third input of the second and of the first logical circuit, respectively, and on the other hand to a second input of the fifth and of the sixth logical circuit, respectively. The outputs of the third and of the fourth logical circuit are connected to a second input of the fourth and of the third logical circuit, respectively. Thus, pulses are obtained having an absolute pulse width substantially equal to that of the input signal.

If the dividers by two give off pulses having a pulse width of 50 percent of the period, it is necessary for the absolute pulse width to be reduced to that of the pulses at the input and the output of the first divider by two respectively, through a pulse-width convertor.

In another embodiment of a device for carrying out the method according to the invention, the pulse-width convertor comprises a logical circuit provided with a number of inputs and an output at which a voltage may occur at two levels. The voltage occurs at the first level if at least one of the voltages at the inputs has a first value, while the voltage occurs at the second level if the voltages at the inputs all have a second value. A first input of this circuit is connected to the input or the output of the first divider by two and a second input to the first output of that divider by two wherein pulse width conversion is necessary. The remaining inputs of the logical circuits are connected to the outputs of the preceding logical circuits.

In another embodiment of the device for carrying out the method according to the invention, the pulse-width convertor comprises a bistable element which is provided with two inputs and is switched by a signal at the first input into a first state and by a signal at the second input into a second state. the first input is connected, if required with the interposition of an inverter stage, to the input of the first divider by two and the second input to a second output of that divider by two wherein pulse conversion is necessary. This circuit arrangement requires a smaller amount of wiring.

The pulses of the pulse sequences appearing at the outputs of the latter embodiment are not distributed regularly, which makes a very disagreeable impression on the ear. A more regular distribution can be obtained by connecting each of the output terminals to a divider by n , where n is at least 2⁵. The output signals of this divider by n should correspond to the tones of the highest desired octave so that the said irregularities are reduced to a value acceptable for a listener. Since the frequencies of the octave tones are unambiguously determined by the frequency of the master oscillator, in a further advantageous embodiment of a device for carrying out the method according to the invention, the master oscillator is rendered continuously and/or stepwise detunable. Thus, the pitch of an instrument provided with these oscillators can be adapted to that of other instruments or be transposed. Moreover, the continuous detuning provides a possibility of obtaining special effects, for example, for imitating a Hawaiian guitar. The lower octave tones are each time derived from the tones of the higher octave by means of dividers by two.

The invention will now be described more fully with reference to the following Figures, of which:

FIG. 1 illustrates how a tone of a given frequency can be built up of different pulse sequences,

FIG. 2 shows a circuit arrangement for obtaining the desired frequencies by addition,

FIG. 3 shows a few associated pulse sequences,

FIG. 4 shows a similar circuit arrangement, in which the frequencies are obtained by subtraction,

FIG. 5 shows a few associated pulse sequences,

FIG. 6 shows a divider by two comprising logical circuits,

FIG. 7 shows the associated pulse sequences,

FIG. 8 shows a pulse-width convertor comprising a logical circuit, and

FIG. 9 shows the pulse sequences associated with this circuit,

FIG. 10 shows a pulse-width convertor comprising a bistable element,

FIG. 11 shows the associated pulse sequences, and

FIG. 12 illustrates the improvement of the pulse distribution after passage of the pulse sequence through three dividers by two.

Referring now to FIG. 1, f_0 denotes the pulse sequence at the input of a first divider by two, f_1 the pulse sequence at the second output of the first divider by two, f_2 the pulse sequence at the second output of the second divider by two, f_3 the pulse sequence at the second output of the third divider by two, f_4 the pulse sequence at the second output of the fourth divider by two and f_5 the pulse sequence at the second output of the fifth divider by two.

The lowest sequence illustrates how to build up the frequency indicated by the number 1, 1010 by adding together the pulse sequences f_1 , f_2 and f_4 . This pulse sequence may also be obtained, however, by subtracting the pulse sequences f_3 and f_5 from the pulse sequence f_0 . It can be clearly seen that the pulses of each subsequent pulse sequence are located at least approximately midway between the pulses of the preceding divider by two.

FIG. 2 shows a circuit arrangement in which the various tones are obtained by adding together the various pulse sequences. The operation is as follows: the pulse sequence at the output of the master oscillator 0 having a frequency f_0 standardized at 10.000 000 000 0 in the binary system is applied to the input of a first divider by two D_1 , a first output of which is connected to the input of the subsequent divider by two D_2 and so forth up to D_{11} . Pulse sequences appear at the outputs of D_1 at a frequency of 2^0 times f_0 at the outputs of D_2 at a frequency of 2^{-1} times f_0 , at the outputs of D_3 at a frequency of 2^{-2} times f_0 , at the outputs of D_4 at a frequency of 2^{-3} times f_0 , and so forth up to pulse sequences at the outputs of D_{11} at a frequency of 2^{-10} times f_0 . The tones are now built up by connecting each of the outputs of the dividers by two, of which the power of 2 in the binary number of the tone is indicated by a 1, to an input of an adding circuit in the form of an "OR" gate A_n , at the output of which pulse sequences will appear corresponding to the pitches of the desired tones. In the Figure, this is illustrated for the tones D flat, D and B flat in the tempered tuning, the frequencies of which relative to the C in the binary system correspond to 1.000 011 110 1, 1.000 111 110 1 and 1.110 010 000 1, respectively. For the sake of clarity, the connections and the "OR" gates for the remaining tones are not shown. FIG. 3 shows the pulse sequences appearing at the input of the first divider by

two D_1 and at the outputs of the first four dividers by two D_1 , D_2 , D_3 and D_4 . The pulses f_1 , f_2 , f_3 and f_4 are used to control the respective dividers by two. From a second output of the respective dividers by two are derived the signals f'_1 , f'_2 , f'_3 and f'_4 which have an absolute pulse width equal to that of the signal f_0 at the input of the first divider by two D_1 . In the lowest sequence, a sum signal is indicated having a frequency f_s equal to $1,011 \times f'_1$. FIG. 4 shows a circuit arrangement in which the desired frequencies are obtained by subtracting pulse sequences from the pulse sequence appearing at the input of the first divider by two D_1 . The circuit arrangement again comprises a master oscillator 0 which may include a pulse shaper, the signal of said master oscillator 0 being applied to an input of the first divider by two D_1 , a first output of which is connected to an input of the second divider by two D_2 which in turn supplies through a first output a control signal to a third divider by two D_3 , and so forth up to the last divider by two D_{11} . The signal f_0 at the input of the first divider by two D_1 is moreover applied to an input of each of eleven adding circuits in the form of "AND" gates A, each "and" gate A corresponding to a tone from the octave to be formed. The second outputs of the dividers by two D_2 to D_{11} are each connected to an input of those "AND" gates A which are associated with a tone built up of the frequencies composed of pulse sequences corresponding to the power of two associated with the relevant dividers by two. This is illustrated in the Figure for the tones G flat, G and A flat built up of the frequencies 10-0, 100 101 100 0, 10-0, 100 000 001 0 and 10-0, 011 010 011 0, respectively. FIG. 5 illustrates the pulse sequences at the input of the first divider by two D_1 and at the outputs of the first four dividers by two and the difference signal f_1 of the pulse sequence f_0 at the input of the first divider by two D_1 and at the second outputs of the second and of the fourth divider by two D_2 and D_4 at a frequency of 1,011. Since these signals are applied to an "AND" gate, there is a possibility of the pulse sequences f_0 being shifted due to the delay of the pulse sequences at the output of a divider by two relative to the pulse sequences at the input of this divider by two. This results in the pulses f_0 being not entirely suppressed so that a narrow needle is left, as shown in dotted lines. The narrow needle N_1 is due to the still small shift of the pulses f'_2 and the slightly wider needle N_2 to that of the pulses f'_4 . Therefore, the signal f_0 is preferably inverted through an inverter stage I to $\bar{f}_0$ so that the maximum permissible delay time of the pulses at the outputs of the divider by two is equal to the pulse width b of the signal f_0 . The resulting difference signal is indicated by f_{r_2} . It will be appreciated that in these circuit arrangements at a delay time equal to zero the absolute pulse width of the signals f'_1 to f'_{10} is allowed to be at the most 150 percent of the pulse recurrence period of f_0 and at least equal to said period.

The dividers by two used in the above circuit arrangements each supply an output pulse having an absolute pulse width equal to that of the input pulse. Such an arrangement is shown in FIG. 6 and comprises logical circuits each provided with a number of inputs and an output at which a voltage may occur at two levels, the voltage occurring at the first level if at least one of the voltages at the outputs has a first value, while the voltage occurs at the second level if the voltages at the inputs all have a second value. The input signal is ap-

plied to a first input K both of a first and of a second logical circuit L₁ and L₂, respectively. The outputs A and B of the first and of the second logical circuit L₁ and L₂, respectively, are connected to a first input of a third and of a fourth logical circuit L₃ and L₄, respectively, the respective outputs C and D of logical circuits L₃ and L₄ are connected to a first input of a fifth and of a sixth logical circuit L₅ and L₆, respectively, whose respective outputs E and F are connected on the one hand to a first and a second output terminal E and F, respectively, and on the other hand to a second input of the first and of the second logical circuit L₁ and L₂, respectively. The outputs A and B of the first and of the second logical circuit L₁ and L₂, respectively, are moreover connected on the one hand to a third input of the second and of the first logical circuit L₂ and L₁, respectively, and on the other hand to a second input of the fifth and of the sixth logical circuit L₅ and L₆, respectively. The respective outputs C and D of the third and of the fourth logical circuit L₃ and L₄, respectively, are connected to a second input of the fourth and of the third logical circuit L₄ and L₃, respectively.

The truth Table associated with this circuit arrangement is as follows:

K	A	B	C	D	E	F
0	1	1	1	0	0	1
1	1	0	0	1	1	1
0	1	1	0	1	1	0
1	0	1	1	0	1	1
0	1	1	1	0	0	1, and so on.

It should be obvious to those skilled in the art that each of the logical circuits L1 through L6 is an "AND" gate of the inverting type commonly referred to as a "NAND" gate. FIG. 7 illustrates the voltages occurring at the various points of this circuit arrangement and it appears therefrom that the pulse sequences E and F have the same absolute pulse width as the input signal.

Since, however, not every type of divider is capable of supplying such output pulses, though being capable of supplying pulses having a pulse width of 50% at the period, it may be required for the pulse width, before the signals are applied to the adding circuits, to be reduced to that at the input of the first divider by two by means of a pulse-width convertor. FIG. 8 shows such a pulse-width convertor comprising a logical circuit L provided with a number of inputs and an output at which a voltage may occur at two levels, the voltage occurring at the first level if at least one of the voltages at the inputs has a first value. The voltage occurs at the second level if the voltages at the inputs all have a second value. The first input of the logic circuit L is connected to the input of the first divider D₁ by two and to a second input is connected to the first output of that divider requiring pulse width conversion, for example, D₁. The remaining inputs of the logical circuit are connected to the outputs of the preceding logical circuits associated with the dividers by two (D₂ and D₃) requiring pulse width conversion.

FIG. 9 illustrates the pulse sequence f_0 appearing at the input of the first divider by two D₁, the pulse sequences f_1, f_2, f_3 and f_4 appearing at the first outputs of the divider by two D₁, D₂, D₃ and D₄, respectively, the pulse sequence f_1' formed in the logical circuit L₁ and the pulse sequences f_2' and f_3' having the frequency of the output signal of the 2-dividers D₂ and D₃. The desired signal f_4' then appears at the output of the logical circuit L₁. An additional advantage of this circuit ar-

angement is that the pulses of the pulse sequences f_2', f_3' etc. are not delayed in time as the leading edges of these pulses are determined by the signal at the input of the first divider by two D₁. This circuit arrangement may have the disadvantage that a comparatively large number of connections are required. This is avoided in a circuit arrangement as shown in FIG. 10, in which the pulse-width convertor comprises a bistable element B_n which is provided with two inputs 1 and 2 and which is brought into a first state by a signal at the first input 1 and into a second state by a signal at the second input 2. The first input 1 is connected with the interposition of an inverter stage I to the input of the first divider by two D₁ and the second input 2 to a second output of the divider by two requiring pulse width conversion, for example, D₂. FIG. 11 shows the pulse sequences occurring in this circuit arrangement, i.e. the pulse sequence f_0 at the input of the first divider by two D₁, the pulse sequence $\bar{f}_0$ at the output of the inverter stage I and hence at the first inputs of the bistable elements B₁, B₂ and B₃ and the pulse sequences at the outputs of the divider by two D₁, D₂ and D₃ and at the second inputs 2 of the bistable elements B₁, B₂ and B₃ and the output signals f_1', f_2', f_3' of said bistable elements. The trailing edge of the output signal of the bistable elements B_n is determined by the leading edge of the signal $\bar{f}_0$ so that any time delays in the dividers are neutralized up to the maximum pulse width of the original signal.

Irregular pulse sequences appear at the outputs of all these adding circuits, which makes a very disagreeable impression on the ear. When these signals are applied to a further chain of dividers, the distribution of these pulses becomes gradually more regular, as shown in FIG. 12. In this Figure, the pulse sequence f_1 is a pulse sequence which may actually occur, for example, the sum signal f_s of FIG. 3. The pulse sequence $f_{s/2}$ shows the pulse sequence f_1 after passage through a first divider by two by the pulse sequence $f_{s/4}$ after passage through a second divider by two and the pulse sequence $f_{s/8}$ after passage through a third divider by two. It appears therefrom that the irregularities have strongly decreased; the pulse width ratio in the pulse sequence f_1 , which in this case varies from 1 : 1 to 1 : 3, has now been reduced to a maximum value of 1 : 2 and 4 : 7 respectively. In FIGS. 2 and 4, these dividers are denoted by C₁, C₂, etc.

In the circuit arrangements of FIGS. 2 and 4, the oscillator 0 is continuously and stepwise detunable. By choosing each detuning step to be equal to half a tone, a transposition can be carried out in a simple manner. Due to the continuous detuning, the pitch of the whole apparatus can be accurately adapted to that of other instruments with which it may be played. In addition, this detuning provides the possibility of obtaining special effects, for example, the imitation of a Hawaiian guitar, in that detuning takes place over a given range each time when a key is depressed.

What is claimed is:

1. A method of simultaneously producing all the tones of a musical scale, comprising the steps of generating a first tone at least as high as the highest required tone, dividing the first tone by a plurality of different factors, each equal to 2ⁿ, where n is an integer while maintaining the absolute pulse width of each divided tone equal to the absolute pulse width of the first generated tone, thereby forming a plurality of pulse sequences, and combining selected groups of the pulse

sequences as a sequence of individual pulses equal to the algebraic sum of the sequences of individual pulses within a selected group to produce from each combined group a single tone of the musical scale.

2. A method as claimed in claim 1, wherein the step of combining selected groups of the pulse sequences comprises adding the pulse sequence of the selected groups.

3. A method as claimed in claim 1, wherein the step of dividing comprises dividing the frequency of the generated first tone by a factor of two to form a first pulse sequence, and dividing the frequencies of each formed pulse sequence by a factor of two to form the plurality of pulse sequences.

4. A method as claimed in claim 3, wherein the step of dividing the frequencies of each formed pulse sequence further comprises positioning with respect to time the pulses of each pulse group, approximately midway between two adjacent pulses of the pulse group having the next highest frequency.

5. A device for simultaneously producing all the tones of a musical scale, comprising means for generating a first pulse sequence having a constant frequency at least as high as the highest tone of the scale, each pulse of the first pulse sequence having a pulse width approximately equal to 50 percent of the period thereof, a plurality of frequency divider means connected to the pulse sequence generator for providing an output frequency equal to one half that of the input frequency and an output absolute pulse width equal to the absolute pulse width of the first pulse sequence, means for connecting the dividers in series with an output of each divider connected to an input of another divider, a plurality of or-gates each corresponding to a tone of the musical scale, and means for connecting the equal absolute pulse width outputs of different groups of selected dividers to inputs of corresponding or-gates, thereby forming pulse trains corresponding to the tones of the scale at the outputs of the or-gates.

6. A device as claimed in claim 5, wherein each of said dividers comprises six AND-gates, means for connecting the input of the divider to inputs of the first and second AND-gates, means for cross-coupling the first and second AND-gates, means for connecting the output of the first AND-gate to inputs of the third and fifth AND-gates, means for connecting the output of the second AND-gate to inputs of the fourth and sixth AND-gates, means for cross-coupling the third and fourth AND-gates, means for connecting the output of the third AND-gate to an input of the fifth AND-gate, means for connecting the output of the fourth AND-gate to an input of the sixth AND-gate, means for connecting the output of the fifth AND-gate to an input of the first AND-gate, means for connecting an output of the sixth AND-gate to an input of the second AND-gate, means for connecting the output of the fifth AND-gate to an output terminal of the divider, and means for connecting the output of the sixth AND-gate to a second output terminal of the divider.

7. A device as claimed in claim 5, wherein the frequency of the means for generating the first pulse sequence is equal to N times the highest tone of the scale, and further comprising a separate digital divider having a division factor of N connected to the output of each or-gate.

8. A device as claimed in claim 5, wherein the means for generating the first pulse sequence is continuously and step wise detunable.

9. A musical instrument provided with a device as claimed in claim 5.

10. A device as claimed in claim 5, wherein the serially connected output of each divider means provides an output frequency equal to one half the frequency on the input terminal thereof and an output absolute pulse width equal to the input period, and wherein each divider means further comprises a pulse width converter means connected to the means for generating the first pulse sequence for reducing the absolute pulse width of each divider means to approximately the absolute pulse width of the first pulse sequence.

11. A device as claimed in claim 10, wherein the pulse width converter means comprises a separate AND-gate corresponding to each divider means and having an input terminal connected to the serially connected output terminal of each corresponding divider means, each AND-gate having a second input terminal connected to the means for generating the first pulse sequence, and means for connecting an output of each AND-gate to an input terminal of each AND-gate corresponding to a lower frequency, the outputs of each AND-gate comprising a pulse series, each having an absolute pulse width equal to one half the period of the first pulse sequence.

12. A device as claimed in claim 10, wherein each pulse width converter means comprises a bistable device switchable to a first stable state in response to an input pulse on a first input thereof and switchable to a second stable state in response to a pulse on a second input thereof, means for connecting an output of each divider to the second input of a corresponding bistable element, and means for connecting the pulses of the first pulse sequence to the first input of each bistable element.

13. A device for simultaneously producing all the tones of a musical scale, comprising means for generating a first pulse sequence having a constant frequency at least as high as the highest tone of the scale, each pulse of the first pulse sequence having a pulse width of approximately 50% of the period thereof, a plurality of frequency dividers each having an output frequency equal to one half that of the input frequency applied thereto and having an output absolute pulse width smaller than 150 percent of the period of the first pulse sequence and at least as large as the absolute pulse width of the input pulses applied thereto, means for connecting the dividers in series with the output of each divider connected to the input of a different divider, and logic circuits corresponding to each tone of the musical scale, and means for connecting the outputs of different groups of dividers to the inputs of corresponding logic circuits, thereby forming pulse trains corresponding to the tones of the scale at the output of the logic circuits.

14. A device as claimed in claim 13, wherein each of said dividers comprises six AND-gates, means for connecting the input of the divider to inputs of the first and second AND-gates, means for cross-coupling the first and second AND-gates, means for connecting the output of the first AND-gate to inputs of the third and fifth AND-gates, means for connecting the output of the second AND-gate to inputs of the fourth and sixth AND-gates, means for cross-coupling the third and

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fourth AND-gates, means for connecting the output of the third AND-gate to an input of the fifth AND-gate, means for connecting the output of the fourth AND-gate to an input of the sixth AND-gate, means for connecting the output of the fifth AND-gate to an input of the first AND-gate, means for connecting an output of

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the sixth AND-gate to an input of the second AND-gate, means for connecting the output of the fifth AND-gate to an output terminal of the divider, and means for connecting the output of the sixth AND-gate to a second output terminal of the divider.

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